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EVERY DAY

JULY 1 1916 SERIAL NO. 110

THE MENTOR

THE WEATHER

By C. F. TALMAN
Of the United States Weather Bureau

DEPARTMENT OF
SCIENCE

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Old Probabilities

SHALL tomorrow's weather be fair or foul? Blow wind—blow moistly from the South, for I go afishing. "Nay, good friend," exclaims the golfer, "the day must be dry and the wind in the west." The farmer moistens his finger and points it toward the sky. "Rain, come, quickly, for my crops," is his prayer. But the maiden's voice is full of pleading: "Let the sun shine tomorrow that my heart may be light on my wedding day."

* * *

AND so, through the days and seasons, humanity with all its varied needs, turns anxiously, entreatingly to Old Probabilities. And how is it possible for him to satisfy the conflicting demand? He may, on the same day, please the farmer in the West, the fisherman in the South, the golfer in the northern hills, and the bride in the eastern town. But how can he suit them all in one locality on a single day? Old Probabilities is willing and he loves humanity, but his powers and privileges are limited. There are those who say that it is due to the kind endeavors of Old Probabilities to satisfy everybody that our weather has at times become so strangely mixed.

* * *

OLD Probabilities is a gentle family name and came out of the affection of the people. The name was a matter of pleasantry. It was given to the Chief of the United States Weather Bureau when the department was first established by Congress, and its source lay in the phrase, "It is probable," with which all the weather predictions began. But Old Probabilities, genial prophet and lover of his fellow men, is passing away, for the officer who organized the Weather Bureau became in time displeased with the name and changed the form of the daily prediction so as to read, "The indications are." The phrase is formal and severe. There is naught but cold comfort in it. Our hearts turn back fondly to Old Probabilities and his friendly assurance: "It is *probable* that tomorrow will be fair."

Chickamauga Park, Tenn., in an Ice Storm

THE WEATHER

By CHARLES FITZHUGH TALMAN

Librarian of the U. S. Weather Bureau

THE MENTOR · DEPARTMENT OF SCIENCE · JULY 1, 1916

MENTOR GRAVURES

- CENTRAL OFFICE OF THE U. S. WEATHER BUREAU, WASHINGTON, D. C.
- A SIMPLE WEATHER STATION
- A MAJESTIC CUMULUS CLOUD
- THE OBSERVATORY ON MONTE ROSA
- LAUNCHING A METEOROLOGICAL KITE
- THE EFFECTS OF SNOW AND ICE—THE CAMPUS, PRINCETON UNIVERSITY

IT is easy to lay too much stress upon the unimportant aspects of weather. It furnishes a bit of conversation over the teacups; it accentuates the twinges of rheumatism; it spoils a holiday. All this, however, is mere byplay.

The real work of the weather—the work that explains the existence of costly weather bureaus, such as the one upon which our Government spends more than a million and a half dollars annually—is momentous beyond calculation. Consider such facts and figures as these:

The head of the British Meteorological Office recently declared that bad weather costs the farmers of the British Isles about one hundred million dollars a year. In our own country it has been estimated that a difference of one inch in the rainfall occurring during July in six States means a difference of two hundred and fifty million dollars in the value of the corn (maize) crop. The world over, the damage wrought by hailstorms is said to average about two hundred million dollars a year. In the city of Galveston a single hurricane once destroyed twenty million dollars' worth of property and six thousand human lives. Thus we might proceed indefinitely.

The fact is that man's welfare is conditioned to an enormous extent and in an endless variety of ways by the vicissitudes of the atmosphere;

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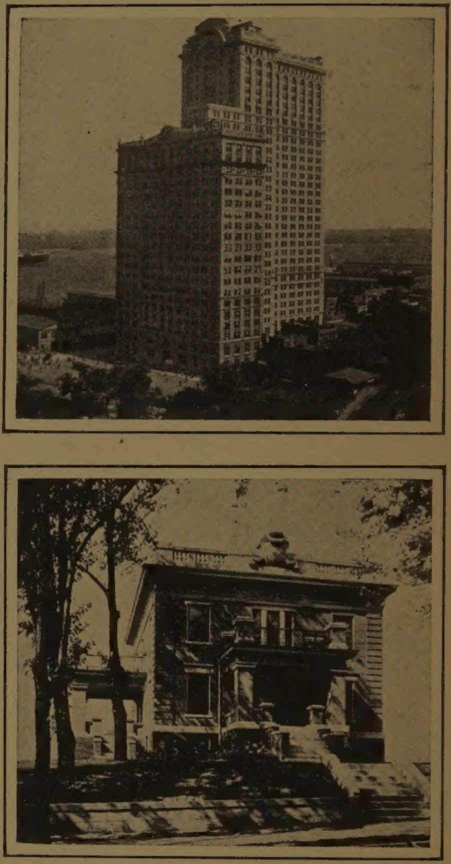
hence the study of weather—meteorology—is one of the most important of sciences. It is also one of the most strikingly neglected!

At the office of the Weather Bureau in Washington there is a meteorological library of some thirty-five thousand volumes. But meteorological libraries are rare; meteorological books are scarce in other libraries; and meteorologists are so uncommon that whoever declares himself one is likely to be asked, "What *is* a meteorologist?"

The "meteors" studied by the meteorologist are not shooting stars, but the phenomena of the atmosphere,—rain and snow, cloud and fog, wind and sunshine, and whatever else enters into the composition of weather and climate.

THE ATMOSPHERE

The ocean of air in which human beings live, even as deep-sea fishes live at the bottom of the liquid ocean, is called the *atmosphere*. Unlike the liquid ocean, it diminishes rapidly in density from the bottom upward. At an altitude of three and one-half miles it is only half as dense as at sea-level. This is higher than the highest permanent habitations of man. Mountain-climbers and balloonists have attained greater altitudes; but above a level of about five miles the air is too greatly rarefied to support life. Balloonists who ascend still higher must carry a supply of oxygen with them. A little above the ten-mile level the air is only one-eighth as dense as at sea-level. The atmosphere extends at least 300 miles above the earth, at which height its density is computed to be only one two-millionth as great as at sea-level.



STATIONS OF THE UNITED STATES WEATHER BUREAU

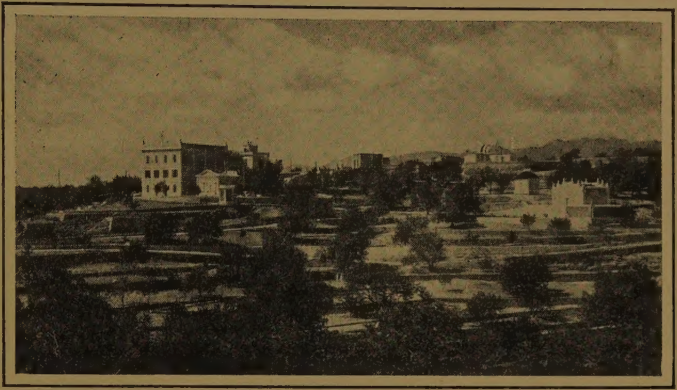
Showing two extreme types: one, an office on the twenty-ninth floor of the Whitehall Building, New York City, with instruments installed on the roof; the other, an independent observatory building, with free exposure on all sides, at St. Joseph, Mo.

The weather with which human beings are concerned may be said to extend upward seven or eight miles; *i.e.*, to the level of the higher clouds. The layer of the atmosphere lying between sea-level and the upper cloud level has certain characteristics that distinguish it from the air above it, and is known as the *troposphere*.

The heating of the atmosphere by the sun is the beginning of all weather, and the temperature of the air is the most important weather element. As soon as we begin to study atmospheric temperature, we encounter a paradox. The heat of the air is all derived from the sun

THE NEW IDEA IN WEATHER OBSERVATORIES

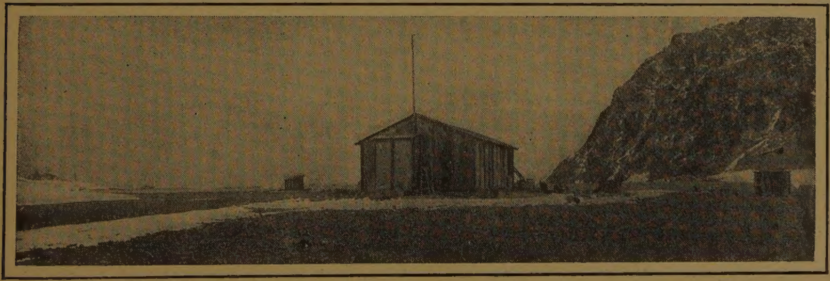
The Observatory of the Ebro (Spain), founded by Spanish Jesuits, is devoted to studying the interrelations of sun, earth and air. Its admirable equipment includes apparatus for the direct and spectroscopic study of the sun, for measuring solar radiation, atmospheric electricity, earth currents, terrestrial magnetism, and earthquakes; besides the ordinary routine of a meteorological observatory. The results of all these observations are published side by side, to facilitate comparison



(except a minute quantity from the interior of the earth, and an infinitesimal quantity from other heavenly bodies), and it would therefore seem at first glance that the upper layers of the atmosphere should be warmer than the lower. Experience proves the reverse to be the case. A mountain overgrown with tropical vegetation on its lower slopes is, if high enough, crowned with eternal snows. A thermometer carried upward in the air shows under average conditions a fall of temperature of one degree (Fahrenheit) for every 300 feet of ascent. This fall of temperature with ascent continues to the upper limit of the troposphere, where the average temperature is something like 70 degrees below zero.

Above the troposphere is a region called the *stratosphere*, or *isothermal layer*, in which an ascending thermometer shows irregular and generally small changes of temperature—not infrequently a rise of temperature with ascent. The exploration of the stratosphere is one of the most fascinating fields of meteorological research, but lies somewhat beyond the scope of an essay on weather. It is carried out chiefly with the aid of small free balloons, some of which (sounding balloons) bear self-registering thermometers and other instruments, while others (pilot balloons) bear no instruments, but show by their movements the drift of the air currents. The greatest altitude ever attained by a sounding-balloon was 21.8 miles; by a pilot-balloon, 24.2 miles. The branch of meteorology dealing with the study of the upper air is called *aërology*.

Reverting to the temperature of man's environment, the reason why the atmosphere is warmest at the bottom is this: The sun's rays come to



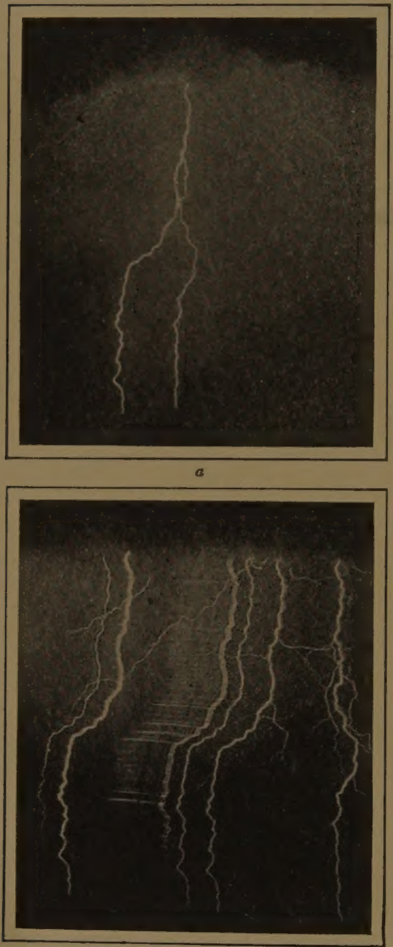
The Argentine meteorological station in the South Orkneys. Once a year an expedition is sent from Buenos Aires to relieve the staff of four observers. This is the southernmost permanently inhabited spot on the globe; and it has not even wireless communication with the rest of the world

A LONELY OUTPOST ON THE VERGE OF THE ANTARCTIC us from outer space in the form of vibrations in the ether, and warm the air to only a slight extent in passing through it. They are absorbed by the ground, and converted into heat waves. The air is then warmed by contact with the warm ground. Lastly, the warming of the lower air gives rise to air-currents, which distribute the heat through the atmosphere.

BAROMETRIC PRESSURE

If our weather were uniform, it would furnish little matter for conversation; in fact, would hardly be weather at all. Changeableness is the salient feature of weather, and to understand weather changes one must know something about barometric pressure.

Like all other forms of matter, the invisible air has weight. At sea-level it exerts a downward pressure averaging 14.7 pounds to the square inch. Atmospheric pressure is measured by means of an instrument called the *barometer*, in which the weight of the air is balanced against a column of mercury. As the height of the mercurial column varies with the pressure of the air, and is taken as the measure of the latter, we follow the practice of expressing pressure (a force) in linear units (inches or millimeters). This practice is retained even in the use of the aneroid barometer, which contains no mercurial column. Hence, when we say that the average barometric pressure at sea-level is 29.92 "inches," we are really expressing in a roundabout way the weight of the air at that level.



Courtesy of U. S. Bureau of Standards and Popular Science Monthly.

HOW THE CAMERA ANALYZES LIGHTNING

The same flashes photographed with (*a*) a stationary camera, and (*b*) a camera revolving on a vertical axis. One of the flashes is seen to have consisted of several successive discharges along an identical path

Barometric pressure not only varies somewhat regularly with altitude—diminishing as we ascend—but also less regularly from place to place in a horizontal direction, and from time to time at a given place. In studying the weather meteorologists frequently wish to compare the barometric pressures prevailing at a certain time at a number of places lying in the same horizontal plane. Given a system of meteorological stations scattered over a certain territory, the first step is to secure simultaneous readings of the barometers at these stations. Then, if the stations are at various altitudes, as they commonly are, corrections must be applied to the readings to reduce all to a common plane; the plane adopted for this purpose is sea-level. Since most stations are *above* sea-level, and since atmospheric pressure diminishes with altitude, reduction to sea-level generally involves applying an *additive* correction.

THE WEATHER MAP

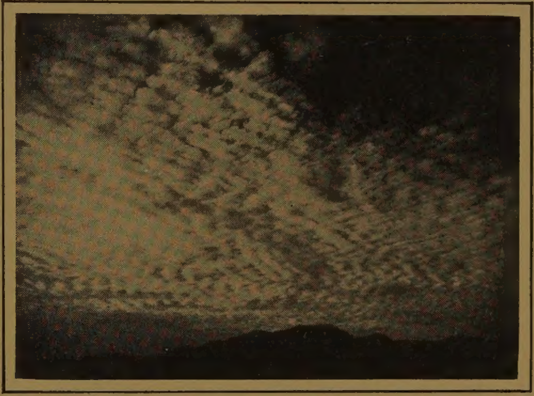
Now please attend carefully to what follows; because I am going to attempt to put into a minimum number of words the essential facts concerning the *weather map*, the best clue to weather mysteries yet devised by man.

At about 200 stations of the Weather Bureau, distributed over the United States, the barometer and other meteorological instruments are read twice a day; *viz.*, at 8 A. M. and 8 P. M., eastern standard time. The readings are promptly telegraphed in cipher to Washington, where they are entered on a map.

The barometer readings at the different stations, reduced to sea-level as just explained, will vary, say, from 29 to 31 inches. Lines, called *isobars*, are now drawn through places having the same pressure; the intervals between the lines corresponding to differences in pressure of one-tenth of an inch. Lines (*isotherms*) are also drawn to connect places having the same temperature, a little arrow at each station shows the direction of the wind at that point, and various other symbols are used to facilitate the interpretation of the map; but the isobars are more important than anything else.

CIRRO-STRATUS

The appearance of this cloud precedes by a day or so the arrival of rainy and stormy weather

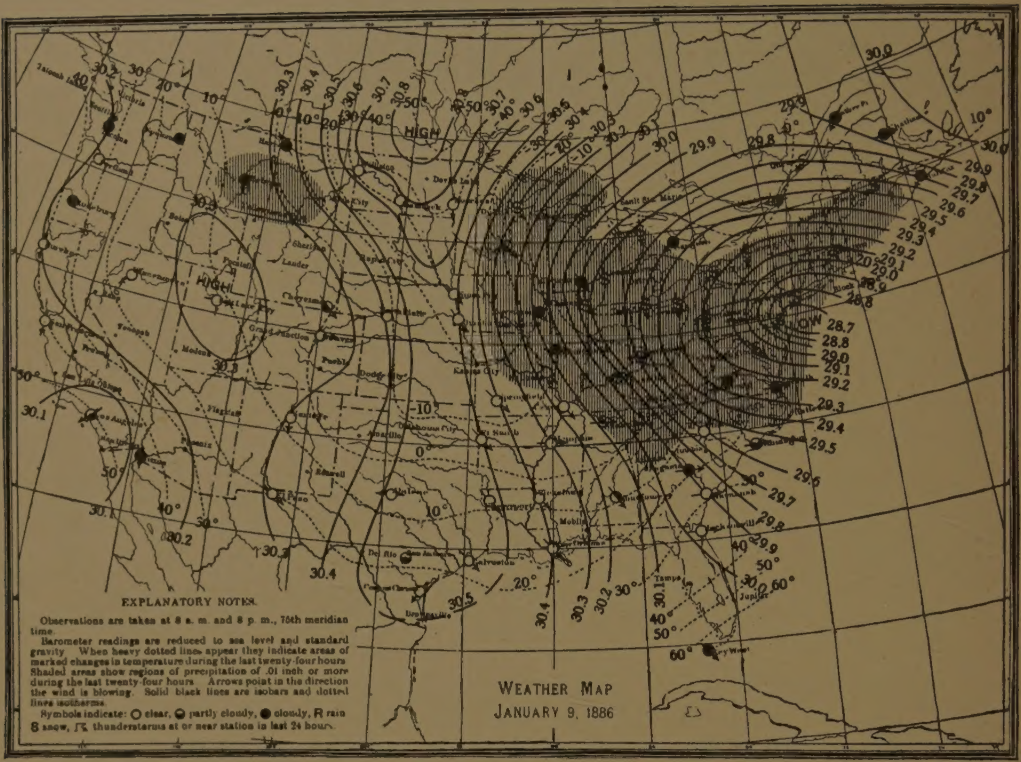


ALTO-CUMULUS

FAIR WEATHER CUMULUS

This cloud marks the summit of an ascending air current, and appears toward midday or early afternoon in the warm season. When the air rises powerfully to great heights, cumulus is built up in mountainous masses and may become cumulo-nimbus, the thundercloud.

Here is the weather map for the morning of January 9, 1886. The solid curved lines are isobars, representing barometric pressures ranging all the way from 28.7 to 30.8 inches. It will be seen at a glance that these lines tend to assume roughly circular forms, inclosing regions where the pressure is lower or higher than the average. Moreover, the little arrows (which "fly with the wind") show that the winds round a



EXPLANATORY NOTES.

Observations are taken at 8 a. m. and 8 p. m., 75th meridian time.

Barometer readings are reduced to sea level and standard gravity. When heavy dotted lines appear they indicate areas of marked changes in temperature during the last twenty-four hours. Shaded areas show regions of precipitation of .01 inch or more during the last twenty-four hours. Arrows point in the direction the wind is blowing. Solid black lines are isobars and dotted lines isotherms.

Symbols indicate: ○ clear, ◒ partly cloudy, ● cloudy, R rain, S snow, ⌈K thunderstorms at or near station in last 24 hours.

WEATHER MAP
JANUARY 9, 1886

center of low pressure tend to blow in a direction contrary to that followed by the hands of a clock (in the southern hemisphere the reverse is true), but instead of blowing in circles are inclined somewhat inward toward the center. Round a center of high pressure (in the northern hemisphere) the typical circulation of the winds is exactly opposite ("clockwise," and inclined outward), though the accompanying map does not show this particularly well.

An area of low pressure, with its system of winds, is called a *cyclone*, or *low*. An area of high pressure, with its system of winds, is called an *anticyclone*, or *high*. Note that a cyclone is not necessarily a storm, though the one shown on this map, with its center not far from New York City, was a very violent storm, which, when this map was drawn, was sweeping up the Atlantic coast. (Popular usage applies the term "cyclone" to the tornado.) The strength of the winds in a cyclone depends upon the contrast in barometric pressure

ASCENT OF A SOUNDING BALLOON
The first made in the United States; at St. Louis, Mo., in 1904

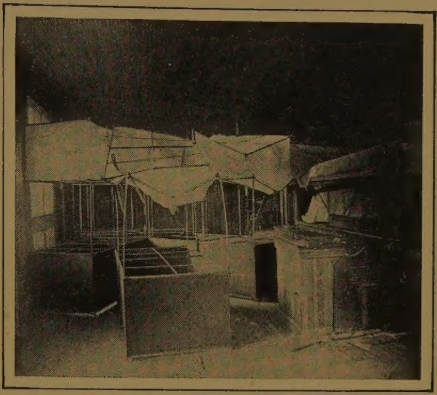
between its center and its outer border. A cyclone with crowded isobars always has strong winds; when the isobars are widely spaced the winds are gentle.

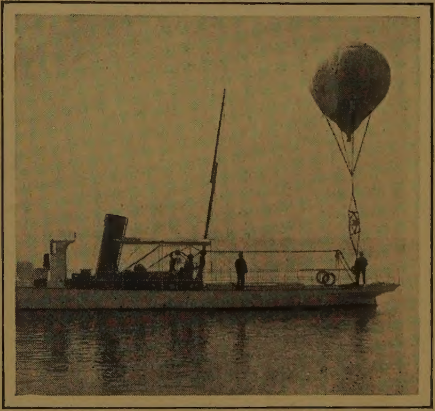
These areas of low and high pressure, in addition to their movements about their centers, move bodily across the country, in a general west-to-east direction, at an average speed of over 500 miles a day. This double movement may be compared to that of a carriage-wheel, rotating and advancing at the same time. Most of our cyclones enter the country from the Canadian Northwest—though many come from other regions—and nearly all of them pass off to sea in the neighborhood of the Gulf of St. Lawrence. Their route across the country varies greatly, depending in part upon the season.

THE WEATHER IN CYCLONES AND ANTICYCLONES

Barometric pressure is not an element of weather, in the ordinary sense of the term, since the fluctuations of pressure that occur in the human environment are entirely inappreciable to the senses. We have seen, however, that pressure is intimately related to wind, which is a weather element of much importance. In noting that systems of high and low pressure are constantly traveling across the country, and that they are accompanied by winds having fairly definite characteristics in relation to each, we have taken an important step toward bringing order out of the (to the uninitiated) chaotic sequence of weather. Obviously, a system of telegraphic weather reports makes it possible to keep close watch of these wind systems, and, from their locations on today's weather map, to form some idea where they will be tomorrow. Thus the weather forecaster is enabled to give notice of the imminence of those violent winds that destroy life and property at sea, and, to a less extent, on land. There is an element of uncertainty in such predictions—since storms, unlike railway trains, are not confined to fixed routes and regular schedules—but the practised forecaster acquires an instinct that helps him to forestall their vagaries.

Now what is true of wind is also true to a certain extent of the other elements of weather,—they bear typical relations to the distribution of atmospheric pressure. Cyclones are usually preceded by rising temperature


THE KITE HOUSE AT AN AEROLOGICAL OBSERVATORY
Some of the kites are much the worse for wear after flying in a storm


SENDING UP A METEOROLOGICAL BALLOON ON LAKE CONSTANCE
Between Switzerland and Germany

HOARFROST

Minute crystals of ice deposited from the air. Under a magnifying-glass they show a variety of beautiful forms

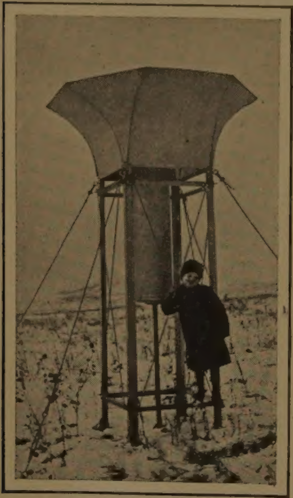
and accompanied by cloudiness and rain or snow; anticyclones are usually preceded by falling temperature and attended by fair weather.

Referring again to the map of January 9, 1886, and following the course of the isotherms, or temperature lines, we see that abnormally cold weather prevailed over the Middle Western and Southern States. The isotherm of zero dips far south across northern Texas, Arkansas, Mississippi, Alabama, and Tennessee; while in the upper Mississippi and Missouri Valleys the temperatures were from 20 to 40 degrees below zero. These regions were, in fact, in the grip of a severe "cold wave," which had entered the country a day or two before, preceding the anticyclone here seen central north of Dakota. Cold northwesterly winds were sweeping over the Great Plains, and as far south as the Gulf.

The same map shows typical weather accompanying the cyclone central on the Atlantic coast. From the seaboard west to the Mississippi Valley rain or snow had fallen within the previous twenty-four hours (indicated by shading), and snow (indicated by S) was falling at the moment of observation at a majority of stations within this area. Elsewhere in the same region the weather was cloudy.

The foregoing remarks indicate in a general way the significance of the weather map and the principles upon which scientific weather predictions are based. The endless procession of highs and lows brings to any place on the map constant alternations of heat and cold, storm and sunshine. The forecaster watches the procession, and draws his inferences as to what will happen in this or that part of the country within the next day or two (forty-eight hours is about the limit of his outlook). "Long-range" forecasting is still a thing of the remote future. Forecasts for a week in advance, are, indeed made by the Weather Bureau with the aid of reports from a chain of stations extending round the globe, but these are in very general terms.

In January, 1914, the Bureau began publishing a "daily weather map of the Northern Hemisphere." This publication is, at present, suspended on account of the war.



MARVIN RAIN AND SNOW GAGE

With trumpet-shaped wind-shield at top. In the middle is seen the cylindrical collector. This is removed and weighed with its contents to ascertain the amount of rain or snow that has fallen

SOME WEATHER MISCELLANIES

It would require a book, rather than a brief essay, to describe all the vicissitudes of weather, and many books that attempt to do this have been written.* We have space here only to mention a few important features of the weather met with in our own country.

The southern and southeastern part of a cyclone, some hundreds of miles from the center, is a favorite breeding-ground for *thunderstorms* and *tornadoes*. Thunderstorms of the type known as "heat thunderstorms" also occur with no special relation to cyclonic centers in regions where the ground has been intensely heated. In either case the storm is built up by rapidly ascending air, which cools and condenses its water vapor, first into enormous clouds (*cumulo-nimbus*, or "thunderheads"), and then into rain, frequently accompanied by hail. It would be necessary to go to some length to explain the familiar electrical manifestations of the thunderstorm—some points, indeed, are not perfectly clear to meteorologists—but it should be stated that these are always the result, not the cause, of the storm. *Lightning* is an electrical discharge between cloud and earth, or cloud and cloud, and *thunder* is simply the violent sound-wave set up by the sudden expansion of the heated air along the path of the discharge,—the same acoustic phenomenon that accompanies an ordinary explosion.

THE EFFECTS OF AN ICE STORM AT CANTON, N. Y.
March 25-27, 1913

SUMMIT HOTEL AT SUMMIT, CAL.
On March 18, 1911. A three-story building whose first story is buried under twenty-six feet of snow

A *tornado* (popularly miscalled a "cyclone") is an extremely violent vortex in the air, usually less than 1,000 feet in diameter. Besides its very rapid rotary motion, it has a

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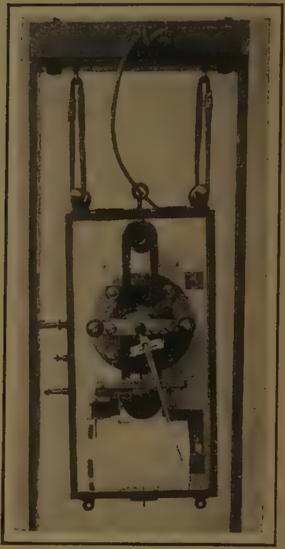
*See "Brief List of Meteorological Textbooks and Reference Books," 3d ed., by C. Fitzhugh Talman. For sale by the Superintendent of Documents, Washington, D. C. Price 5 cents.

Courtesy of the Scientific American

A WATERSPOUT NEAR BEAUFORT, N. C., IN AUGUST, 1911



TURPAIN'S THUNDERSTORM RECORDER

Or ceraunograph. This is one of several instruments designed to register the natural electric waves, or "strays," which sometimes interfere seriously with the transmission of wireless telegrams. Strays are often generated by lightning discharges, near or distant, and this instrument therefore serves to give notice of an approaching thunderstorm

progressive motion at a speed averaging forty or fifty miles an hour. Its position at any moment is marked by a black funnel-shaped cloud, which grows downward from the sky and does not at all times reach the earth. A waterspout at sea is an identical phenomenon, though usually less violent. Along its narrow path the tornado demolishes everything,—wooden houses are blown to splinters, trees uprooted or stripped of their branches, structures of heavy masonry laid in ruins. Something like a hundred lives are lost each year in these storms, on an average, and one of them (St. Louis, May 27, 1896) destroyed thirteen million dollars' worth of property.

A *blizzard* is a high, cold wind, accompanied by blinding snow, which in winter sometimes blows out of the front of an advancing anticyclone, especially in our North-Central States. A similar wind, with or without snow, is called in Texas a *norther*.

A *chinook* is a warm, dry wind that descends the eastern slope of the Rocky Mountains in Montana, Wyoming and Colorado, and flows northeastward over the plains. Its effects are most pronounced in winter, when it brings about a very sudden rise in the temperature —in extreme cases as much as forty degrees in fifteen minutes! It causes snow to vanish as if by magic, and is appropriately nicknamed the "snow-eater."

IN THE WAKE OF A TORNADO

The tornado destroyed a house and barn, but left a path in the center with practically no harm done

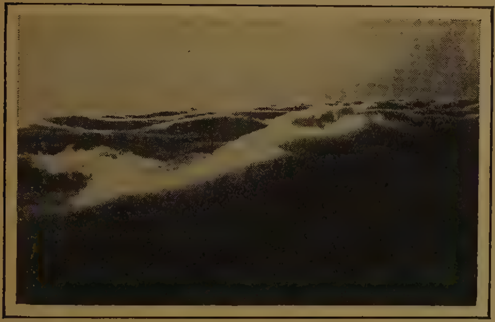
"*Cloudburst*" is merely a picturesque name for a very heavy shower; usually a thunder-shower.

West India hurricanes occasionally visit the United States, especially in the late summer and early autumn. These storms begin as violent cyclones of small extent (300 to 600 miles in diameter), usually somewhere east of the West Indies, sweep in a long curve across the Caribbean Sea, and then turn north, either passing up along the Atlantic Coast or crossing the Gulf of Mexico into the southern United States. Soon after entering the temperate zone they increase in size and diminish in violence, but are still vigorous enough on reaching the Gulf or South Atlantic Coast to cause great devastation. Low-lying shores are often inundated by the immense waves they generate.

Cold waves are the rapid and severe falls in temperature that sometimes occur in winter, especially at the front of an anticyclone. Warnings of these occurrences, issued by the Weather Bureau twenty-four to thirty-six hours in advance, often result in the saving of millions of dollars' worth of merchandise susceptible to damage by freezing.

Frosts in the spring and autumn are also predicted with great success, to the immense advantage of farmers, market-gardeners, and horticulturists. The practice of smudging or heating orchards, now so widespread, is usually carried on under the advice of the Weather Bureau, which gives prompt notice to the orchardist when such precautions are in order. The bureau publishes charts showing the average and extreme dates of the last frost in spring and the first frost in autumn for all parts of the country.

A *fog* is a cloud resting on the surface of the earth. In the United States fog is commonest along the northern and middle parts of the Atlantic and Pacific Coasts. In the interior of the country, especially the western part, it is of rare occurrence, the average number of days a year with fog being less than ten.



LOOKING DOWN ON A SEA OF FOG FROM MT. TAMALPAIS, CALIFORNIA

Lastly—weather fallacies are rife. *Indian summer* is merely a type of mild, hazy, heavenly weather that prevails intermittently during our long American autumns. The *equinoctial storm* is a myth; the climate has not "changed" anywhere within the span of a human lifetime (one year differs from another, but there is no progressive or permanent change); and the *moon* has nothing whatever to do with THE WEATHER.

SUPPLEMENTARY READING

CLIMATE AND WEATHER	*By H. N. Dickson*
AMERICAN WEATHER	*By A. W. Greely*
WEATHER SCIENCE	*By R. G. K. Lempfert*
SOME FACTS ABOUT THE WEATHER Second edition.	*By W. Marriott*
METEOROLOGY The latest general textbook on the subject in English.	*By W. I. Milham*
FORECASTING WEATHER	*By W. N. Shaw*
ELEMENTARY METEOROLOGY	*By F. Waldo*

Consult also the numerous publications of the United States Weather Bureau, which will be found in most public libraries.

***Information concerning the above books and articles may be had on application to the Editor of The Mentor.

THE OPEN LETTER

"What is lightning and what causes it?" The question came to us a few days after we had made announcement of a "Weather" number of The Mentor. It was a natural question, for lightning is the most sensational of all weather phenomena. It has always had a fearful sort of fascination for humanity. To the ancients it came as a bolt of wrath from the hand of Jove. To the fire-worshippers it was a warning message. To parched travelers it was a bright promise, for it heralded the coming of rain. To the superstitious it was a signal flash from the spirit world. And to those of nervous temperament it was a highly disturbing phenomenon producing emotions varying from uneasiness and alarm to hysteria. The question then, "What is lightning and what causes it?" has an interest for all. I referred it to Mr. Talman, the author of the Mentor article on "The Weather." His reply follows.

* * *

"Not so many generations ago 'natural philosophers' thought that inflammable gases, exhaled from the earth, took fire spontaneously in the air, and that this was lightning. The idea also prevailed—and it is not yet quite extinct—that a stroke of lightning involved the hurling down from the sky of a mass of rock, called a 'thunderbolt.' In the eighteenth century people became quite familiar with the process of generating, by friction, a mysterious something called 'electricity,' which, when it passed from one body to another through a small layer of intervening air, produced sparks. Several philosophers noticed the resemblance between these sparks and lightning. It remained, however, for Benjamin Franklin to prove that lightning was really an electrical discharge on a large scale. The experiments by which he proposed to demonstrate this were successfully performed, first by others, in France, and then, by Franklin himself, at Philadelphia. With the aid of his famous kite he drew down from a thundercloud a little of the 'electrical fluid' (as it was then called), and produced tiny sparks from an iron key at the lower end of the wet kite-string.

"We do not even yet know what electricity is, but we know a great deal about the way it behaves and the effects it produces. There are two kinds of electricity, which we call *positive* and *negative.* A body is said to be *charged* when it has an excess of either kind, and the two kinds have a tendency to unite and neutralize each other's effects. Thunderclouds become heavily charged with electricity. We are not quite sure how this happens, but it is now commonly believed that the strong uprising currents of air that occur in the storm, in the process of breaking up the water-drops in the cloud also separate positive from negative electricity; leaving the former in excess in the part of the cloud next to the earth, and carrying the latter far aloft.

"By a process called 'induction' the positive charge in the cloud draws an excess of negative electricity to the surface of the ground underneath. The stronger the contrast between these opposite charges, the harder they try to break through the interposing barrier of the air (which is a poor conductor of electricity) and to neutralize each other. At length they succeed in doing so. A powerful stream of electricity flows for an instant between cloud and earth. Its passage heats the air and makes it luminous—just as the passage of an electric current heats the filament of an electric lamp and makes it luminous. This is lightning.

"These discharges occur not only between the clouds and the earth, but also, and probably more often, between clouds charged with opposite kinds of electricity.

"The sudden expansion of the heated air along the path of the discharge affects our ears just as does the sudden expansion of the air at the mouth of a gun when it is fired. In each case a wave is sent through the air in all directions from the place of disturbance, and our ear-drums are set in vibration. That is thunder."

* * *

Take courage then, you timid ones, who wince in the lightning's flash and tremble under the thunder's roll. Thunder is simply a vibration of your ear drums—and, when you hear the thunder, be assured, all danger is over.

W. D. Moffat

EDITOR

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